GOVERNING THE INNOVATION COMMONS:

PRIVATE ORDERING OF INTELLECTUAL PROPERTY RIGHTS

Working Paper prepared for:
The Political Economy Doctoral Workshop
Department of Government, LSE

March 2005

Anthony Williams
Department of Government
London School of Economics and Political Science
Houghton Street
London WC2A 2AE
England UK

adw@anthonydwilliams.com

GOVERNING THE INNOVATION COMMONS:

PRIVATE ORDERING OF INTELLECTUAL PROPERTY RIGHTS

Recent critiques of the U.S. patent system have focused on the numerous ways in which the rapid accumulation of property rights in knowledge-intensive industries is raising the cost and uncertainty of commercialising new inventions. Increasingly, firms that wish to commercialise new products and services (while avoiding accidental patent infringement) must first gain access to an overlapping and increasingly dense thicket of intellectual property rights. As private rights accumulate in a given technological domain, the costs of acquiring the rights required to commercialise a follow-on invention can become prohibitively expensive. This raises the further possibility that entire domains of research that might otherwise have been profitable may now be forgone in anticipation of the high costs and uncertainty associated with bargaining for intellectual property rights.

When faced with the prospect that intellectual property rights might be inhibiting innovation in certain industries, most analysts call for property rights to be rolled back, or at least counterbalanced, by some action taken by the courts, the Congress, or international treaties. But, while policy measures are being debated, private actors are taking action, supplying creative solutions to tackle transaction cost problems. Indeed, a close look on the ground reveals a blossoming of new self-organizing institutions to ease the costs of intellectual property rights exchanges.

Three recent developments in biomedical and information technology (IT) industries signal that public lawmaking is not the only arena in which the excesses of intellectual property may be addressed. First, a new decentralized, open, and collaborative innovation paradigm is emerging in which the rights to intellectual property are shared openly among a community of volunteer contributors. Second, industry participants are cooperating to supply new institutions that lower the costs of exchanging or transferring intellectual property rights, including collective licensing organizations, patent pools, and intellectual property marketplaces. Third, the pervasiveness of property rights has raised awareness of just how important the public domain is, leading a number of firms in high-tech sectors to make major investments in an “information commons” that will pre-empt or undermine the potential property rights of competitors.

All of these private investments in building new institutions to manage intellectual property rights reveal a self-correcting feature of the intellectual property system that has been overlooked until now. This paper presents stage one of my analysis of this phenomenon in which I examine how the interplay between public policy reforms and private ordering strategies shapes the process of institutional adjustment to economic and technological change. In doing so, the paper provides a preliminary theoretical and descriptive framework that will inform a larger empirical study of how self-organizing industry participants are supplying second-best solutions for mitigating transaction costs in a situation where property rights ought never to have been granted in the first place.

o Decentralized lawmaking and the challenge of institutional adaptation

In this paper I argue that the growing investments of private entrepreneurs in building private institutions for governing intellectual property rights represents a critical institutional adjustment to the mushrooming transactional problems that have accompanied recent moves by policymakers to strengthen the intellectual property rights regime in the United States. My argument roughly follows from Robert Cooter's assertion that an increasingly complex economy demands increasingly decentralized lawmaking. As Cooter himself put it:

> "Centralized law, like socialism, is not even plausible for a technologically advanced society. The forces that reversed the trend toward socialism and destroyed central planning are also undermining legal centrism. An advanced economy involves the production of too many commodities for anyone to manage or regulate. As the economy develops, the information and incentive constraints tighten upon public policy. These facts suggest that as economies become more complex, efficiency demands more decentralized lawmaking, not less" (Cooter 1994: 216).

The implication is not, in my view at least, that complexity and rapid change entirely incapacitate a centralized state. But for societies that wish to remain on a stable path of economic growth these forces do impose an imperative for agile and ongoing institutional adaptation; a problem that I will argue is often better resolved when policy-efforts are directed primarily at helping industry participants overcome collective action problems than when they substitute public institutions for private ones.

Several reasons suggest that the recent evolution of new institutions to govern intellectual property rights in high-tech industries provides a fitting context to test and refine this central hypothesis.

First, significant technological and economic changes unfolding since the 1970s are forcing a period of profound institutional adjustment and transition in the U.S. patent system. The 1980s were particularly pivotal, marking a real shift in U.S. policy toward stronger intellectual property rights. Indeed, for some industries, including biotechnology and software, patent protection for new inventions was unavailable until a string of legal precedents reversed prior policy in 1980 and 1981. Thus, in some respects, we have natural experiment (albeit without perfect laboratory conditions) in which to observe how changes in the formal state-supplied framework of property rights have altered the incentive structure facing entrepreneurs, and how entrepreneurs, in turn, have internalised these changes in their competitive and organizational strategies. Moreover, we can observe this transition over a considerable time period, which is advantageous, if, as in this case, our purpose is to discern how changes in formal institutions interact with the private ordering strategies of entrepreneurs to drive a gradual process of institutional adaptation.

Second, the transactional hazards arising in high-tech industries perfectly illustrate the informational constraints placed on public policy-makers in an increasingly complex economy. In the U.S., as in most other advanced industrial countries, the constitutional rules governing intellectual property rights are set by a legislative body (in this case the Congress), the patent system is administered by an independent agency (the U.S. Patent and Trademark Office), and the courts adjudicate disputes that arise in the course of allocating property rights.

Together these formal, state-supplied institutions are tasked with assigning exclusive property rights to the creators of new inventions in a manner that balances the welfare-enhancing properties of innovation with the welfare-reducing effects of monopoly. Balancing these objectives makes the proper specification of property rights a delicate and controversial matter under any circumstance, but there is reason to believe that the task has become measurably more difficult with the rise of new industries characterized by rapid and cumulative innovation. Indeed, for reasons I will explain shortly, it is now next to impossible for policy-makers, the USPTO, or the courts to foresee and accommodate all of the possible contingencies and interdependencies that arise when allocating and adjudicating property rights in complex technological and transactional environments. As a consequence, the burden of ex-post adaptation to adverse circumstances arising from the assignment of property rights frequently falls on private actors. As we shall see, this is not necessarily a bad thing. Indeed, the imperative for ex-post adaptation is the animating force behind the supply of private transaction cost mitigating institutions, which brings me to the third point.

The fact that the intellectual property system appears to exhibit some potential for self-correction provides an opportunity to identify the conditions that encourage or discourage a decentralized approach to institutional adaptation. The idealized system I have in mind is one in which a shared norm/understanding among a close knit group of co-operators evolves into a regularized pattern of behaviour, which may, under certain circumstances, congeal into a formal institution with monitoring and enforcement capabilities, which, if stable and efficient, may be folded into the regulatory apparatus of the state. But, we have only a limited understanding of how and why such private ordering systems emerge and evolve over time. A refined theory of private ordering backed rigorous empirical evidence will provide a valuable input into policy decisions not just in the intellectual property domain, but also across a broad class of policy issues in which collective action problems loom large.[1]

The remainder of the paper proceeds in three stages. Section 2 briefly reviews some of the institutional reforms undertaken in the U.S. patent system since the late 1970s. Sections 3 – 5 examine the consequences of two decades of administrative and legal reform using different empirical strategies. My empirical analysis suggests that while patent data shows a significant increase in the rate of invention in the period following major institutional reforms, the statistics mask a reality that is rife with strategic behaviour and serious transactional hazards. Section 6 looks briefly at the solutions that private actors are generating to cope with these transactional difficulties, while section 7 provides some positive and normative conclusions.

[1] In this respect, my work on private ordering of intellectual property rights follows in the tradition of Elinor Ostrom’s empirical work on self-governing institutions for managing natural resources (1990), Robert Ellickson’s study of the informal rules and social norms that govern real estate transactions (1991), Curtis Milhaupt and Mark West’s theory of the rise of organised crime (2000), and the work of Avner Greif, Paul Milgrom, and Barry Weingast on the role of self-organization in establishing credible commitment in the medieval trading system (1994).

o **The shifting intellectual property rights environment**

The canonical property rights theory of Harold Demsetz (1967) posits that when a resource becomes more valuable, it is worthwhile to spend more money defining and enforcing property rights over that resource. Demsetz argued that when property rights are well specified over a given resource, that resource will be utilized more efficiently. Property rights give producers the right incentives to produce, and users the right incentives to calculate the social cost of what they use.

This basic mental model is probably what U.S. policymakers had in mind when they set out to reform the patent system in the 1980s and 90s. And, consistent with Demsetz's prediction, U.S. patent law reforms were undertaken to enhance the ability of innovators to internalise the benefits from their R&D investments at precisely the same time that technological and economic changes were raising the commercial value of intellectual property.[2]

There is little doubt that the period beginning in the late seventies and early eighties marks a major shift in U.S. innovation policy. In the previous "anti-patent" era running from roughly 1930-1970, U.S. policy-makers and regulators remained largely suspicious of the power of big business. The courts generally viewed patents as automatic sources of monopoly power and measures were taken to weaken patent rights, most notably by imposing a higher standard non-obvious as a condition of "patentability." But industrial stagnation in the 1970s, and a growing recognition that intellectual assets were becoming an important determinant of economic success, spurred a reassessment of the patent system (FTC 2003).

One of the most significant reforms to come out of this period of restructuring was the creation of the considerably more patent-friendly U.S. Court of Appeals of the Federal Circuit in 1982 (see Table 1 in the appendix for a more detailed chronology of significant legal and legislative reforms since 1980). The new court was significant for several reasons. To begin with, legal administration of the patent system was centralized for the first time, providing more uniform and predictable treatment of patent cases. But more significantly, the court transformed the legal environment from one where it was common for patents to be invalidated by the courts to one where the courts promoted the broad, exclusionary rights of patent owners.[3] Some legal observers claim that the court reversed prior practice by relaxing the standard of non-obviousness for new inventions, making patents easier to obtain, and thereby lowering the average cost of creating a patentable invention.[4]

The new court also made patents stronger and more enforceable by demonstrating a willingness to grant preliminary injunctions and confer large damage awards in patent infringement cases. The most noteworthy case saw Polaroid sue Kodak for infringement of its

---

[2] There is widespread consensus among economists that intangible assets such as knowledge have become more strategically and monetarily valuable since the 1970s. See, for example, Abramovitz and David 1996.

[3] Robert Merges, for example argues that the new court applied a broader interpretation of patent scope and made it more difficult to challenge a patent's validity by raising evidentiary standards. Robert Merges. 1997. *Patent Law and Policy: Cases and Materials, 2nd edition*. Charlottesville: The Michie Company.

[4] Gerald Sobel. 1988. "The Courts of Appeals for the Federal Circuit: A Fifth Anniversary Look at Its Impact on Patent Law and Litigation." *The American University Law Review*. Vol 37: 1087-1139.

instant cameras patent in 1986. Polaroid was awarded $1B in damages and a temporary injunction that barred Kodak from competing in the instant-film camera business. While the unprecedented severity of the penalty was likely intended to establish a credible threat against would-be infringers, its more enduring impact may have been to effectively raise the expected value of patents in the eyes of would-be inventors.[5]

Perhaps most significant, at least in terms of their direct impact on the dynamics of then nascent industries such as semiconductors, software, and biotech, were the string of decisions that enlarged the domain of patentable subject matter. Once again, the court was a driving force behind a series of legal precedents and legislative reforms. Over a twenty-year period, these reforms extended patent coverage to new life forms (micro organisms), software programs, semiconductor designs, business methods, and most recently, nanotechnologies.

All considered, changes in the U.S. patent system ushered in an era of stronger and more valuable intellectual property rights. Some of the changes made patents stronger by making them more enforceable and more likely to be held up in court. Some of the changes made patents easier to obtain by lowering the standards required to obtain them. Further changes expanded the boundaries of who can patent and what can be patented. The net effect was that patents became more cost effective for a wider group of individuals and organizations, and a more expansive realm of new inventions.

One of the arguments I began with was that neither U.S. legislators, the USPTO, nor the courts were likely to foresee all of the possible contingencies and interdependencies that would arise as they set out to restructure the formal system of intellectual property rights. If we can assume that the choices of political actors reflect their subjective modelling of the environment, then one test of this hypothesis is to measure the degree to which outcomes are consistent with intentions.[6]

Over the next three sections I take a close empirical look at the consequences of two decades of administrative and legal reform in the U.S. patent system, mapping what is best described as an explosion in the rate at which firms are patenting new inventions. Despite the surface appearance of success, I find that the aggregate patent statistics mask a reality rife with strategic behaviour and significant transactional hazards.

o **Mapping the patent explosion**

The starting point for my empirical analysis is a comparative growth analysis of U.S. patents using patent data from the U.S. Patent and Trademark Office (USPTO) over a 28-year period

---

[5] High-tech firms in a range of industries noted that the costs associated with being "held-up" by an injunction after sinking considerable resources into the design, manufacture, and marketing of a new product, even on a temporary basis, could be very high indeed.

[6] In case there is any doubt as to whether the true intentions of U.S. policymakers were to strengthen the incentives for innovation, one can consult, for example, the public report of the Industrial Subcommittee For Patent And Information Policy Of The Advisory Committee On Industrial Innovation: *Report On Patent Policy* (1979). Many of the reforms recommended in the report were initiated during the early 1980s. Or, for a more general, but detailed, overview of patent law and anti-trust reforms over that last two decades see a recent Federal Trade Commission report: *To Promote Innovation: The Proper Balance of Competition and Patent Law and Policy* (FTC 2003).

ranging from 1976 to 2003.[7] I pay special attention to the growth of patents in the biotechnology and information technology sectors since many reforms in the U.S. patent system were targeted at these sectors. This comparative growth analysis provides one measure of whether firms were responsive to the new incentives to patent supplied by the U.S. patent law reforms.

The quantitative analysis is supplemented by interviews with twenty intellectual property officers in a sample of IT firms, as well as evidence from the 1994 Carnegie Mellon Survey (CMS) on the nature and determinants of industrial research and development in U.S. manufacturing industries (Cohen, Nelson, & Walsh, 2000). These additional sources provide critical supplementary information that aids in the interpretation of the quantitative results. Since much of the subsequent analysis is reported at length in a separate paper (Williams 2004), I will simply summarize some of the main conclusions from that paper.

At first glance, aggregate patent data suggests that the U.S. patent law reforms undertaken by the Congress and the courts were very successful indeed. Changes implemented in the early 1980s, such as the creation of the new centralized court of appeals, were followed by a significant and long-term surge in the rate of patent applications and grants. Figure 1, which shows the total number of patent applications and grants for all U.S. utility patents between 1976 and 2003, reveals that patent applications to the USPTO have more than tripled since 1980 with an average annual growth rate of 6.5%, while patent grants have more than doubled with an annual average growth rate of 5%.[8]

How statistically significant is this break in the patent application and grant series? While my time-series only extends back as far as 1976, a similar analysis by Bronwyn Hall shows that the average annual growth in patent applications and grants between 1950 and 1983 is merely 0.3% (Hall 2003).[9] A t-test for a structural break in the series in 1984 (given by the difference in means between two periods, i.e., 1950-1983 and 1984-2003) is highly significant, with a p-value of less than 0.0005.

What does the data reveal about how the incentives to patent new inventions have been internalised across different industries? An analysis of patents in technology subclasses

---

[7] The use of patent data in economic analysis has been pioneered by a number of scholars whose work has been influential in guiding the approach taken here (e.g., Bessen and Hunt 2004, Cohen et al. 2000, Hall 2003, Griliches 1990, Lerner 2000, Schankerman 1986, Scherer 1982). Indeed, patent data provides a very rich and potentially fruitful source of data for the study of innovation and technological change. When combined with outside sources of data such R&D spending and other firm characteristics, analysis of patent data over time gives us information about the inventive performance of firms and industries, the development of technologies and industries, and the strategies that firms deploy to attain competitive advantage from their intellectual capital and inventive output. For an overview of this technique see Hall, Jaffe & Trajtenberg 2000.

[8] It is worth noting that the patent explosion is not confined to the United States. An OECD analysis of patent data around the world indicates that the rate of patenting is increasing in most major centres of the global economy where similar patent reforms have been implemented, including Europe, Japan, and more recently, Brazil, China, and India (OECD 2004). Patent applications to the European Patent Office, for example, totalled nearly 110,000 in 2002 – about a third of the applications submitted to the USPTO – but grew at an average rate of 4.8% between 1985 and 1993, and 7.8% since 1993.

[9] The USPTO's database includes searchable electronic files for all patents starting from 1976. If one wishes to go back further in time it becomes necessary to inspect the physical records on file with the USPTO.

reveals that patent growth is quite unevenly distributed. Patents in the chemical and pharmaceutical subclasses exhibit very little growth until the mid-1990s, while patents in mechanical technologies grew at about 5% each year since 1984 (i.e., roughly proportional to the aggregate growth rate). The largest share of patent growth, on other hand, can be attributed to IT-related inventions, including computers, communications, microelectronics, and consumer electronics (see figures 2-4).[10]

What happens when the unit of analysis shifts from patents in broad technology classes to patents held by firms in broad industry classes? A few interesting facts emerge from this analysis. First, on average, firms in the IT industry (including computers, consumer electronics, microelectronics, and telecommunications) currently obtain up to 5 times as many patents per million R&D dollars as firms in comparable industries, including highly inventive biotechnology firms (figures 5 - 8).[11] Perhaps even more striking is that fact that the share of patents granted to IT firms has risen from approximately 20% in 1976 to nearly 60% by 2003. When measured this way, the growth in patent applications witnessed in chemicals, mechanical, and other technologies appears to be driven partly by firms not traditionally in these industries. This suggests two key findings: 1) IT firms increased their patenting not only in their own sector but in other technology sectors as well, and 2) a vastly disproportionate share of the explosion in patent applications and grants can be attributed to IT firms.

If the analysis ended here we might safely reach two conclusions regarding the program of patent law reforms undertaken in the 1980s and 1990s. First, we could conclude that U.S. policymakers effectively boosted the rate of invention (as measured by patents) in most U.S. industries by offering stronger protection for intellectual property rights. Second, given the concentration of patent growth in the IT sector we might conclude that the reforms targeted at this sector (such as the extension of patent protection to software and semiconductors) were particularly effective. These conclusions would appear to disprove my hypothesis that U.S.

[10] Figure 2 shows that the annual number of IT patents issued by the USPTO has been growing steadily since the early 1980s with an average annual growth rate of 10.3% (more than twice the 5.0% growth of overall patent grants). In 2003, the USPTO issued nearly 70,000 IT patents, almost 6 times as many as were being issued during the late 70s and early 80s. Figure 3 reveals that IT patents are not simply rising with the overall tide of patents. Rather, IT patents have grown significantly as a proportion of overall patents issued by the USPTO, and are now approaching close to 40% of patents issued on an annual basis. Figure 4 disaggregates total IT patents into its sub-classes. While all sub-classes have grown, patents in the ‘computers and office equipment’ and the ‘microelectronics’ categories grew more rapidly and account for a larger share of the IT category than ‘telecom’ or ‘consumer electronics’ patents.

[11] Figures 5 shows the aggregate R&D expenditures for firms in the computer, microelectronics, and pharmaceutical industries between 1981 and 2000.Over the twenty-year period I examine, absolute spending more than doubled in the computer and office equipment industry, grew 6-fold in the pharmaceutical sector, and increased by 10 times in the microelectronics industry. Figure 6 gives us a different perspective, showing the same figures represented as a proportion of overall business expenditure on R&D. One obvious implication is that while the proportion of patents in the IT industry has gone up significantly, the proportion of total U.S. R&D spending attributable to firms in the IT industry has not, and, in fact, that proportion has gone down. Figure 7 shows the patent propensity ratio for all R&D performing U.S. firms from 1981 to 2000 (patent propensity measures the ratio of patent grants to R&D spending). Somewhat surprisingly, I find the average propensity to patent has remained relatively constant for U.S. firms as a whole (hovering between 0.5 to 0.7 patents per million dollars of R&D spending), despite changes in the legal and economic environment that encouraged firms to seek patents. Figure 8 compares the patent propensity ratios for firms in the computer and office equipment industry, the microelectronics industry, and the pharmaceutical industry.

policymakers were unlikely to adequately forecast the path of technological and economic change and adjust state-supplied institutions and regulatory frameworks appropriately.

The analysis, however, should not end here, because a closer look at the dynamics unfolding in the IT industry reveals that the patent statistics mask some very significant trends. First, a naïve casual interpretation of the relationship between the patent law reforms and rising patent propensities actually misspecifies the true relationship by failing to include a significant variable: namely, the rise of defensive patenting. Second, the patent explosion in the IT sector is creating serious transactional difficulties that threaten to undermine rather than stimulate innovation. In the end, it appears that U.S. policy-makers failed to anticipate many of what would emerge to be the most salient issues facing innovators in high-tech industries, including the growing modularity and complexity of technology, the increasingly fast pace of innovation, and the cumulative nature of invention itself.

o Cumulative invention and the rise of defensive patenting

Two inter-related empirical facts indicate that apparent association between patent law reforms and the patent explosion is not, as it first appears, a simple function of stronger intellectual property rights providing more potent incentives to innovate.

First, the results of the patent analysis are seemingly at odds with the results of the Carnegie Mellon Survey of nearly 2000 U.S. R&D performing firms (Cohen et al. 2000) that demonstrate that the absence of patent protection would have little impact on the innovative efforts of most firms in most industries. This research provides two surprising insights into the value firms attribute to patents. First, patents are not the exclusive, or even the primary, device for protecting inventions in most industries. Second, some industries—especially the pharmaceutical and medical device industries—rely much more heavily on patents than others (see figures 9 & 10).

Isolating respondents in IT industry (communications, computers, and semiconductors) from the rest of the sample reveals that for the vast majority of their inventions, firms gain proprietary advantage on the basis of appropriation mechanisms such as secrecy, lead-time, learning curve advantages, and complementary sales and manufacturing capabilities. Patents, on the other hand, rank last among appropriation mechanisms in the communications and semiconductor sectors, and third out of five in the computer and office equipment sector by a small and probably statistically insignificant margin (see figure 11). The apparent gap between the relative effectiveness of patents and their widespread use suggests that there are reasons other than protecting innovation that must explain why firms in the IT industry patent as prolifically as they do.

When this glaring paradox was put to my sample of industry informants the second reason for discarding the naïve causal interpretation of the patent explosion became clear. My informants uniformly submit that firms in the IT industry amass large patent portfolios for strategic and defensive reasons entirely unrelated to protecting innovation (at least in the conventional sense). More specifically, they claim that the primary drivers of patenting are to a) defend themselves against infringement suits and hold-up strategies, and b) gain access to industry IP on favourable terms through cross-licensing agreements.[12] Similar conclusions

[12] Generally speaking, in a cross-licensing agreement two firms agree to grant reciprocal access to one another's intellectual property, such that each firm may use other firm's intellectual property for whatever

reached by the authors of the CMS survey lead me to believe that the testimony from my informants is representative of the broader industry (figure 12).[13] But, to understand why this is so it helps to know a little about the nature of invention in high-tech industries and what this implies for the intellectual property system.

The patent system was designed with discrete standalone inventions is mind. These comparatively simple technologies can be found in industries where chemical composition is a central aspect of design such as pharmaceuticals, in the consumer and packaged goods industry, and in industries producing rather simple instruments and devices. As Richard Nelson observes "On the input side, discrete inventions typically do not incorporate a large number of interrelated components; they stand more or less alone. On the output side, the products of discrete technology industries tend not to comprise an integral component of a larger product or system; they therefore do not enable the development of a wide array of ancillary products" (Nelson 1989).

However, in a growing number of industries where complex systems technologies are the norm, technical advance proceeds in an altogether different fashion. First, a useful end product typically comprises many different components, each of which may be invented independently (see figure 13). Second, the evolutionary path of technology is typically cumulative or sequential in the sense that today's advances build on and interact with many features or components of existing technology (see figure 14). The core technologies developed in the aerospace, automotive, computers, defence, and semiconductor industries all have features that one would attribute to cumulative systems technologies.[14]

Many of the assumptions about the benefits of intellectual property rights that hold in the case of discrete technologies, do not hold in industries characterized by cumulative invention and multi-invention products. With respect to the strategic use of patents, for example, the key difference between cumulative and discrete invention industries boils down to whether a new product or process comprises numerous patentable elements versus relatively few. New drugs and chemicals, for example, typically comprise a relatively small and discrete number of patentable elements, reflecting the nature of technical advance in these industries. This feature of the underlying technology enables firms to acquire enough patents to afford a level of exclusivity that is sufficient to capture monopoly rents through commercialisation or licensing.

---

commercial purpose without fear of reprisal. In essence, both firms give up some of the exclusivity offered by a patent in exchange for greater overall freedom to design new products and services.

[13] The authors conclude that firms in IT industry overwhelmingly patent to maintain their freedom to design and commercialize new products and services, and that this freedom is won by accumulating a patent portfolio that can be used for defensive purposes. The survey results and the observations from my informants receive additional support from the empirical fact that over the same time period that U.S. patent reforms were being implemented, IT firms were undertaking managerial reforms of their own. Many firms overhauled their patent procedures by hiring in-house patent attorneys, rewarding employees for patentable inventions, and setting up internal patent committees to support a more aggressive "patent mining" strategy.

[14] For good overview of the distinction between discrete and complex technologies, see Richard Nelson's paper, "Capitalism as an engine of progress," 1989, *Research Policy*, . For an elaboration on the implication of cumulative invention for patent policy, see Robert Merges and Richard Nelson. 1994. "On limiting or encouraging rivalry in technical progress: the effect of patent scope decisions." *Journal of Economic Behavior and Organization*, 25:1-24.

In contrast, computer hardware, software, and semiconductor products, for example, tend to comprise a large number – often hundreds, and even thousands – of patentable elements. In such cases, firms rarely gain proprietary control over all of the essential complementary components of many of the new products they are bringing to market. Firms hold rights over technologies that others need, and vice versa, creating a condition of mutual dependence where no firm can move ahead with developing and commercialising a new technology without first gaining access to complementary technology. In such cases, a firm holding a patent on one essential element can use the threat of blocking others from commercializing their products to extract hefty licensing fees or to gain access to rival technology on favorable terms.[15]

This dynamic of mutual interdependence suggests that a large proportion of the sheer volume and accelerating rate of patenting in the IT industry can be explained by the constant need to strengthen one's position in cross-licensing negotiations and fend off infringement suits.[16] As the costs and risks of patent litigation and hold-up in the IT industry grow, firms invest in large patent portfolios that will create a credible threat of a counter suit. Or, as interviewees commonly referred to it, a state of "mutually assured destruction."[17] As long as the risks remain balanced, major patent owners can avoid the possibility of a breakdown in commercialisation by agreeing to a cross-license that confers reciprocal access to one another's inventions.[18]

While amassing large patent portfolio may mitigate hold-up problems, it's gradually turning out to be a very costly strategy. The problem with the unavoidable overlap of intellectual property rights in the IT industry—and by extension, unavoidable infringement—is that it causes firms to redirect management attention and valuable resources away from more productive uses, generating a great deal of waste in the process.

For instance, many interviewees expressed concern about the fact that all firms must now assume the costly overhead associated with defensive patenting, including the accumulated transaction costs of locating rights holders, monitoring the patent landscape, coping with litigation, and negotiating and enforcing licensing agreements with all of the relevant patent

---

[15] "Hold-up" problems occur when one firm threatens to seek an injunction against another firm that is infringing on its patent, but only does so after the infringing firm has invested millions, if not billions, in a new product or manufacturing process. In doing so, the firm seeking the injunction gains maximum leverage in any cross-licensing negotiations that ensue.

[16] "The concern" as one informant put it "is if you don't patent new inventions you're somehow going to lose position. So the engines have been cranked up to capture all of these inventions. And the companies that do spend a lot of money on R&D get pretty good at it, and hence there are lots and lots of patents that are produced."

[17] Robert Kohn, now Vice Chairman of Borland, expressed the prevailing view among IT firms that the best defense against hold-up and infringements suits is a good offence. "Most of the patents filed, I would argue, in our field, in the software area, are filed for defensive purposes so that if you get sued you'll have a war chest in order to defend yourself, which is precisely what Borland did over the period of time when I was General Counsel. We filed patents on virtually everything. Any innovation in user interface design, flyover help, spreadsheet notebooks -- I mean, you name it, I had my guys file patent applications."

[18] As one executive of a communications equipment firm observed, "Your patents are mostly used in horse trading. You come together and say 'here's our portfolio.' In our industry, things all build on each other. We overlap on each other's patents. Eventually we come to some agreement: 'you can use ours and we can use yours.'"

holders.[19] In the semiconductor industry, miniaturization has made it feasible to put entire electronic systems on a single integrated circuit, but Linden and Somaya (2000) have documented many cases in which difficulties in transacting for multiple property rights over the various components that must be combined in such products are causing significant delays. Similarly, in the biotechnology industry, patents over gene fragments and genetic "research tools," which are used as inputs in making therapeutic medicines, have raised concerns that the "fencing off" of these basic building blocks could significantly slow down progress in biomedical research (Eisenberg 1994).

Another closely related concern is what is known as royalty stacking, wherein the accumulated royalties on new products that combine patented technologies can increase prices and adversely affect the profitability of new products and services.[20] In the biotech and pharmaceutical industries, where a non-exclusive license to a "must have" technology averages between 1-4% of net sales and an exclusive license averages between 6-10%, royalties can easily stack-up to 20% of net sales. While the costs have not been quantified for the IT and software industry, some interviewees estimate that they could be equally, if not more substantial (see my estimate in section 5.3).[21]

Finally, the existing situation amplifies the uncertainty that already surrounds risky R&D investment decisions in high-tech industries. As one interviewee put it "We have witnessed in recent years a vast proliferation of patent grants by a seriously understaffed PTO and an equally vast proliferation of complex litigation over patent validity and scope. Notwithstanding the centralization of patent law development in the Federal Circuit over the past two decades, the governing standards for patentability and patent law jurisprudence generally remain plagued by unpredictability in their application, particularly with respect to patents bearing on new or emerging technologies. The result is pervasive uncertainty about legal rights, both in terms of the ability to enforce one's own patents and the ability to avoid rapidly escalating

[19] Stephen Fox of HP remarked that, "It is without a doubt a serious drag on the technological and scientific progress that the patent system was designed to promote. An unknown but undoubtedly significant number of invalid patents are issued every year; an unknown but undoubtedly significant number of patents generate lawsuits or threatened lawsuits involving overly broad claims. Both phenomena create serious impediments to competition, both from existing products on the market and from new products in the development stage. Litigation has become a poor means of addressing these problems, in part because of the unacceptably high cost and length of the litigation process and in part because of the … unpredictability of litigation outcomes."

[20] Joel Poppen of Micron observes that as the hold-up model becomes more successful, "There's more and more stacking of royalties on top of new products and technologies . . . Eventually those hold-up costs are going to be passed along to consumers in the form of higher prices."

[21] James Pooley, a lawyer in Palo Alto who has represented many software firms, observes that, "In the software industry we have a kind of business that's easy to enter, but where you enter with an overwhelming sense of dread because you don't know how many pieces of IP you will need to operate . . . And there's also the problem that we don't know how much we're going to have to pay. And it can seem overwhelming when someone knocks on your door and ask for five percent of your revenue and you negotiate that, end up paying three, and then surprise, there's someone else who asks for another five or ten percent." Pooley notes that in many instances, the size of the claim is measured by what could happen in the litigation process, rather than by a considered view of the total costs of licensing of all the IP required to commercialize a new product. As a result, says Pooley "you end up with more than a hundred points in the percentage scheme, and that just eats up profit margins and discourages people from pursuing business."

exposures to infringement claims by others. And that uncertainty heightens risks surrounding innovation investment decisions."[22]

All considered, most interviewees agreed that, at the very least, higher transaction costs and royalty stacking create a tax on innovation. Few however, accepted the more extreme argument advanced by Heller and Eisenberg (1998) that transactional problems are creating a tragedy of the anti-commons where valuable intellectual property resources are under utilized because too many patent holders hold overlapping rights to exclude others. Nevertheless, it seems reasonable to assume that the deadweight costs of defensive patenting could turn out to be quite significant in the long run if nothing is done to mitigate the problems.

In the next section I attempt to model strategic behaviour in intellectual property transactions to show that a breakdown in innovation has thus far been averted because everyone loses – both the licensee and licensors – if transaction costs and royalties exceed the net benefits of commercialisation. This potential to realize gains from trade by pursuing a cooperative strategy has allowed a cross licensing equilibrium to emerge. In repeat-play bargaining situations most firms will be able to access to intellectual property rights on reasonable terms most of the time. However, the modelling also reveals that the conditions that have favoured the development of a benevolent cross-licensing equilibrium are in danger of being eroded.

o Modelling strategic interaction in intellectual property transactions

While there is no evidence to suggest that rising patent propensities are causing a systematic breakdown in commercialisation, the existing pattern of use certainly suggests the IT industry would actually be collectively better off if patents (or litigation) were pursued less aggressively, or alternatively, if mechanisms to mitigate adverse effects arising from the defensive use of patents were more widely adopted. Indeed, the situation is easy to recognize as one that has many characteristics of a non-cooperative strategic game in which rational players find it next to impossible to reach optimal outcomes.[23] When viewed from the

[22] Jordan Greenhall, CEO of DivXNetworks, specifically laments what he calls patent FUD – a lack of transparency or lucidity in the patent landscape created by "patent farms" that generate thousands of new patents every year. "As a small company, one of the biggest risks I face is uncertainty in the marketplace. I can minimize my risk by understanding my competitor's products very well, by understanding my products very well, by understanding what the customers want. But I've found in the past year that I really can't understand the patent landscape and that I'm sitting with a nuclear bomb on top of my products that could go off at any point and cause me simply not to have a business anymore." In the end, notes Greenhall, "I have now issued a directive that we reallocate roughly 20 to 35 percent of our developer's resources and sign on two separate law firms to increase our patent portfolio to be able to engage in the patent spew conflict… These patents are not created to protect innovation, but simply ride on the back of innovation to create a zone of obscurity where other companies really don't know what the patent landscape is."

[23] One version of such a game, The Prisoner's Dilemma, is conceptualized as a non-cooperative game in which all players have perfect information. Players can't communicate, or if they can, they can't make binding commitments. Both players prefer the cooperate-cooperate outcome. Both players are also tempted, however, to defect as they gain a greater payoff if they free ride on the contribution of the other player. Since both players assume that the other will free ride, they both opt to defect, yielding a sub-optimal outcome. The game is said to have a dominant strategy in the sense that the player is better off choosing to defect, no matter what the other player chooses. This outcome is a Nash equilibrium because neither player has an incentive to alter their strategy independently of the strategy choice of the other.

perspective of one firm, it seems entirely rational, if not essential to increase and aggressively assert one's stock of patents. But, viewed collectively from the perspective of the entire industry, and society more broadly, the aggregate result of aggressive patent strategies can lead to sub-optimal outcomes for all.

The patent portfolio race game

In the simple one-shot game depicted below, I show the strategy choices of two rival oligopolists that compete in a market for widgets, each of which risks infringing on the IP of its rival. Each player may either choose to add more patents to their growing patent portfolio (thereby strengthening its deterrent against litigation) or choose not to patent (thereby exposing itself to a unilateral risk of hold-up).

		Player B	
		Patent	Don't Patent
Player A	Patent	-1, -1	4, -2
	Don't Patent	-2, 4	2, 2

Patenting by both firms leads to lower net profits because both bear the burden of the costly overhead associated with defensive patenting. Indeed, both firms would be better off if they could agree not to patent, or better still, to refrain from litigating. Both firms also realize, however, that its rival will be sorely tempted to cheat on such an agreement, and might unilaterally seek to strengthen its bargaining position instead. In the end, the dominant strategy is clear: each of the two firms is led to contribute to their patent portfolio, and as each does so, they both do worse than if they had signed a binding agreement or could otherwise restrict the practice of defensive patenting.

However, it is also easy to see that with repeated play, only two players, and the ability to make binding agreements, both firms could arrive at a cooperative solution to the problem. Indeed, we observe that in practice the cooperative solution entails a cross-licensing program that provides reciprocal access to intellectual property such that each firm develops its widgets without fear of litigation.

The evolution of a cross-licensing norm in the IT industry has been until now a reasonably efficient second-best solution to the transactional problems arising from an incentive structure that encourages firms to seek out and aggressively assert as many patents as possible. There is little doubt that the cross-licensing norm remains a key reason why innovation and commercialisation have not systematically broken down in the industry when the growing density of intellectual property rights in the IT sector would otherwise suggest that this is a strong theoretical possibility.

The questions therefore remain: How long can the equilibrium hold? How many players and how many patents before the cross-licensing equilibrium breaks down?

The patent litigation game with asymmetric risk

My observation is that the cross-licensing equilibrium that has been sustained up to this point has been successful for two main reasons. The first reason is that, until recently, the community of major players engaging in cross-licensing programs in the IT industry was relatively small and familiar.[24] Moreover, most firms in the industry were making roughly equivalent contributions to advancing the state of the art. And, as one informant observes, in a cross-licensing negotiation, firms "Like the fact that they are dealing with someone who is a significant innovator and will continue to innovate." The second reason is that the threat of mutually assured destruction has been roughly symmetrical among the firms who engage in cross licensing, and, much like the Cold War, this symmetrical threat helps maintain a balanced equilibrium in the industry.

Today, firms increasingly have to deal with heterogeneity along both dimensions. They not only bargain with many more players, but with multiple types of players as well. The risks are not always symmetrical and the players are not as familiar.

For example, by far the greatest source of consternation among informants is the recent emergence of what many in the industry refer to as "trolls" or "patent terrorists" who acquire patents (often from bankrupt IT firms following the dot-com collapse) with the explicit purpose of prosecuting infringement suits against large firms that are vulnerable to hold-up problems.[25] The problem for many firms is that stockpiling patents does not really solve the problem posed by trolls. Trolls do not actually make any products that would infringe on other firms' patents, so there is not possibility for making counter-suits. As a result, firms routinely face situations where, as one informant put it, "You either pay, or you potentially put your entire business at risk."

Consider the modified game scenario depicted below. In this case we have two players with asymmetric pay-offs. Player A is a large, capital-intensive firm on the verge of rolling out a new billion-dollar product line. Player B is a "non-practicing entity"—or a "patent troll"—with intellectual property rights that may read on the new product of Player A. Player A's first decision is whether to launch the new product. If A decides not to commercialise, she loses

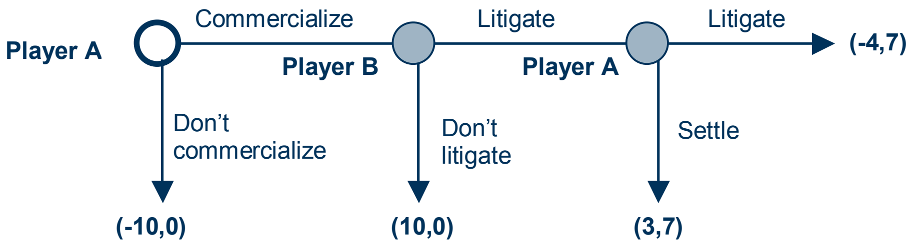
---

[24] Harry Wolin, VP of Intellectual Property at Advanced Micro Devices, notes that, "If you look back to the mid-1980s . . . there was a lot of freedom of action and everybody just competed and it was the same group of players. After that you see a lot of growth and a lot of new companies coming in. And I think the focus turned more from making a reasonable amount of money and moving forward with your business to a new group of CFOs coming in saying 'I'm going to make money off every asset I have.' Patents became one more asset that we had to generate revenue from." Wolin also remarked on the effectiveness of Texas Instruments' use of aggressive patent licensing in the mid-1980s as a strategy to rescue the company from vigorous competition from Japanese semiconductor firms. During his time at Motorola, Wolin was responsible for licensing patents for what he described as relatively cheap rates. "But then," as he put it, "we saw the kind of money that TI was getting for theirs and it was like, 'Hey, what are we leaving on the table here?' "

[25] Robert Barr of Cisco explains that "Obtaining patents has become for many people and companies an end in itself, not to protect an investment in research and development, not to license technology to others who need it, but to generate revenue by 'holding-up' other companies that actually make and sell products without even being aware of their patents. They try to patent things that other people or companies will unintentionally infringe and then they wait for those companies to successfully bring products to the marketplace. They place mines in the minefield. The people and companies – I am not just talking about individuals here – who file these patents and extract license fees from successful businesses play the patent system like a lottery."

her $1B investment for a pay-off of (-10). Player A knows, on the other hand, that by commercialising she gets a pay-off of (10), but there is a 0.7 probability that Player B could win damages and an injunction if a patent infringement suit was initiated, causing her to lose her $1B. By extension there is a 0.3 probability that she would win and proceed unimpeded with her product line. Her probabilistic payoff is therefore (–4).

In the case of litigation, Player B wins $1B in damages with a probability of 0.7 and has nothing to lose, so his probabilistic pay-off is (7). But, since Player B knows A's payoffs, he sets the royalty amount in the case of a settlement at $700m, making his assured pay-off (7), and making Player A's payoff (3). Player A is clearly better off launching the product and settling with Player B so that she can recoup at least a portion of her investment.



This modified game scenario demonstrates that with increasing heterogeneity and asymmetric risk there is no cross licensing equilibrium; just an increasing level of uncertainty and a heightened probability that a growing spew of patent litigation could undermine the incentives to engage in innovation.

Modelling the effects of scale

Asymmetric risk aside, there is reason to believe that the growing scale of the IT industry will become a factor in raising the costs of maintaining the existing cross-licensing equilibrium. Indeed, if recent trends are any guide, then the costs of hold-up, uncertainty, protracted negotiations, and mounting royalties will accumulate as the number of patents and patentees continues to grow.[26] As the costs grow, it is hard to imagine how the cumulative deadweight burden of litigation and cross licensing could not become a substantial drag on the profits of IT firms, and inevitably, the rate of innovation.

While we know the approximate cost of patent litigation, and could fairly easily project what it might be in the future, we don't know much about the costs of cross-licensing negotiations. Yet, industry sources suggest that vast majority of intellectual property disputes are settled out of court, and typically through cross-licensing agreements and side payments (one firm estimated that 98% of its disputes are settled without recourse to litigation).[27] I have

[26] One informant observed that "At some level we're going to have to worry about the half a million patents owned by more than 40,000 parties, and we have to worry about how we're going to negotiate with them. Some of them don't want to negotiate with us. I know how to negotiate with other contributors in the field, but there are some out there who say, 'I just want billions of dollars.'"

[27] The American Intellectual Property Law Association reports that 100 intellectual property disputes go to court each year, 2500 intellectual property suits filed, and hundreds of thousands of demand and notice letters are sent to alleged infringers.

constructed a simple model that illustrates a feasible range of expected costs based on information from my informants and the American Intellectual Property Law Association. I set side payments aside, for now, and focus on the transaction costs of negotiating cross-licensing agreements.[28] To provide a rough approximation of the total sum of transaction costs, I estimate the following equation.

$$\sum_{i=1}^{n} t = \left(\frac{n!}{k!(n-k)!} \right) \pi^* \theta$$

Where,

t = transaction costs

n = the number of firms in the industry

k = the number of parties to a cross-licensing agreement

π = is the proportion of firms that the *i*th firm must establish a cross-licensing agreement with in order to avoid infringement

θ = the average transaction costs associated with the *i*th cross-licensing agreement

Figure 15 shows different estimates of the costs given different assumptions about the range of possible values that the variables can take. Thus, I allow *n* to vary between 0 and 3000 to capture a range of possible values for the number of firms in the U.S. IT industry (see table 1 for the actual number of firms as of 2000).[29] I hold *k* constant at 2, since cross-licensing agreements are, by definition, established between two firms. The first term then gives of the factorial representation of all of the possible combinations of firms in the industry. This provides the total number of cross-licensing agreements that would need to be negotiated if every firm required a bilateral agreement with all other firms in the industry. Since this is a fairly extreme assumption, I fix π at 0.25, 0.5, and 0.75 to derive the number of cross-licensing agreements required given different assumptions about the probability that the *i*th firm will unintentionally infringe on the intellectual property of the *j*th firm.[30] I hold θ constant at US $0.5M, which I believe to be a very conservative estimate, and perhaps even the minimum cost of negotiating a cross-licensing agreement.[31]

[28] Royalties and side payments are important to consider if our goal was to estimate the costs that weigh upon decisions by individual firms to commercialize a given piece of intellectual property in given technological domain. High royalty payments will affect the incentive to innovate in a given domain by reducing expected profits, just as an increasing marginal tax rate can dampen the incentive to work. My interest is in the transaction costs of negotiating the royalty amount, since transaction costs add surplus costs to the industry as a whole.

[29] The actual number of firms in the IT industry in 2000, globally and in the United States, is 2,272 and 1,568 respectively.

[30] The probability of infringement varies according do the density of intellectual property rights in a given technological domain. Patent statistics suggest the density, and hence the probability of infringement, is very high in all sectors of the IT industry, with firms in the software and semiconductors facing an exceptionally high probability of unintentional infringement. One informant in the semiconductor industry suggested that there are 90,000 patents and 10,000 patent holders intellectual property rights

[31] I arrive at this figure from two sources: informants in the IT industry and the average cost of patent litigation as reported by the American Intellectual Property Law Association. It is important to bear in

The model indicates that a conservative estimate of the transaction costs (where n=1500, k=2, π = 0.25 and θ = $US 0.5M) is US $140B—approximately one-sixth of the total revenue of the U.S. IT industry in 1999. These costs escalate to staggering levels as the number of firms and the probability of infringement increases, suggesting a hypothesis that I examine in the next section. My argument is that the existing cross-licensing equilibrium is a transitory phase. The upper bound of the transaction cost estimation above will never be reached. As more and more firms join the industry, as the technology becomes ever more complex, and as property rights accumulate, repeat-players will be driven to repair their trading relationships in a self-help way. The potentially large gains available from lowering the cost of bargaining for intellectual property rights will justify investment in creating more complex institutions for governing intellectual property rights. Evidence suggests that this evolutionary process is already happening.

o Governing the innovation commons

In a world of Coasian bargaining, it is not terribly important that U.S. policymakers failed to “get it right” in the initial restructuring of intellectual property rights. If transaction costs are low and property rights are well defined, then interested entrepreneurs can simply bargain their way from the initial assignment of entitlements to something new. Large-scale private ordering, in other words, can occur after property rights are granted. This, in essence, is the key implication of the Coase Theorem (Coase 1960).

Evidence suggests, however, that transaction costs in intellectual property rights exchanges can, in practice, be very high indeed. The consequence of positive transaction costs is the potential for a breakdown in Coasian bargaining and a failure to realize mutual gain. But, following Oliver Williamson (1977, 1985), we also know that repeat players can and often do take steps to overcome such transactional hurdles—those with a recurring need to transact in intellectual property rights will embed transactions in more protective governance structure that lower the cost of transacting.[32]

This suggests that the state can actually facilitate the creation of private exchange institutions in repeat play settings by granting property right entitlements that will, where necessary, force individual rights holders to assemble their own transactional framework, i.e., a private institution. Private ordering of intellectual property rights thus offers a unique compromise: it addresses the mushrooming transactional hurdle created by new and stronger property rights,

mind that the costs vary according to the amount of revenue at stake. For patent litigation, the American Intellectual Property Law Association reports in its *Economic Survey 2003* that the average total cost to both parties in a single-patent litigation are $1M when the amount of revenue at stake is $1M or less, $4M when the amount is revenue is between $1M and $25M, and $8M when the amount of revenue is $25M or greater. On one hand, it is reasonable to assume that the costs of a cross-licensing negotiation are less than litigation; otherwise there would be little incentive to settle intellectual property disputes in this manner. On the other hand, the amount of revenue at stake in a cross-licensing negotiation is typically in billion-dollar neighbourhood.

[32] It is important to make a distinction between *spontaneous private ordering* of the Coasian kind, which proceeds through autonomous adaptation and spontaneous interactions among industry participants, and *intentional ordering*, which implies cooperative adaptation of a deliberate and purposive kind. While both are interesting, my study is primarily concerned with the latter, i.e., purposive and cooperative adaptations that private actors make to technological and economic change.

while preserving most of the economic incentive advantages that accompany strengthened rights.

As noted in the introduction, a diverse and dynamic set of private institutions has recently emerged. There is, unfortunately, insufficient scope within this paper to present a detailed survey of private initiatives. In lieu of this, let me provide two brief examples and follow up with some ideas about the strategy for conducting further empirical research.

Patent pools

One of the key problems facing innovators in high-tech industries is the need to locate and bargain with multiple individual right holders. As a practical response, these industries have evolved a norm under which patents are used primarily as bargaining chips or “currency” in cross-licensing negotiations. And, under certain circumstances, it is perfectly rational for firms caught in a mutually interdependent cycle of rapid and cumulative research and development to systematically forego full enforcement of property rights in exchange for reciprocal forbearance from competitors. However, as the number of right holders increases, so to do the costs of cross licensing. The patent pool has emerged as simple, but functional solution to this problem.

In a patent pool, property rights are pooled in a collective organization offering uniform terms for their use, thus lowering the costs of exchange with users and other producer. Multiple patent holders, in effect, assign or license their individual rights to a central entity, which in turn sets the rules for valuation of the intellectual property, and then exploits the collective rights by manufacturing, licensing, or both. Most importantly, the pool regularizes technology transactions by providing one location for purchasing rights and by regularizing the valuation of individual patents.

Once established, contributing member firms typically draw freely from the patent pool, while firms outside of the pool can often license the entire package for a fixed fee, thus solving the problem of having to go to multiple patent holders. Such pooling arrangement can provide huge advantages in multi-invention product environments where the combined transaction costs of informing and persuading all of the relevant component suppliers to cooperate in licensing their intellectual property are particularly high.

Historically, patent pools have been used successfully in the aircraft and automotive industries to break through deadlocks in cross-licensing negotiations in the early 1900s. But, in the era of heightened anti-trust enforcement, anything that looked like industrial collusion was frowned upon and, as a consequence, patent pools virtually disappeared from the landscape after 1945 (Merges and Nelson 1994). More recently, patent pools have come back into play. One was recently established by firms that hold patents to the MPEG-2 video compression technology, which is widely used by makers of televisions, DVD players, telecommunications equipment, as well as cable, satellite and broadcast television service providers. Industry informants in the IT industry suggest that more pooling arrangement are currently under negotiation.

Indeed, when patent pools take shape, they collect a host of beneficial transaction under one roof. They result in reduced haggling over the valuation of property rights given the need for repeat dealings. Firms that join patent pools may enjoy the benefits of centralizing administrative and reducing litigation costs. There is the advantage of the potential for expert tailoring and flexibility in rule design and implementation as circumstances change. And, since industry participants often succeed in managing the process without outside intervention, there is the benefit of reduced political economy costs of rent-seeking which may arise under a legislative solution.

On the other hand, there are reasons to believe that the set-up costs of negotiating a pooling agreement will often be steep. One study of patenting pooling arrangements (Lerner & Tirole 2000) found that these costs result from 1) differing assessments of the technological merits of the contributions by members of the pool, 2) private information held by each member concerning the precise characteristics of the technology and 3) strategic bargaining possibilities created by negotiations over the potentially large “pooling surplus” that may results from the creation of a pool. However, the fact that pools have arisen so often in the past, despite these costs, says a great deal about the cost savings that firms expect from these arrangements.

Defensive publishing and the pre-emption of property rights

As an alternative to patent pools, a growing number of firms are electing to forgo patent protection altogether, and choosing, instead, to publish patentable research results. Publishing rather than patenting is gaining popularity as an IP strategy because its low cost simplicity. Publishing results in groundbreaking research domains raises the prior art bar, preempting the ability of competitors to obtain patents that could fence off and foreclose technological options. When scientific knowledge and technology are evolving rapidly, firms that publish rather than patent can still maintain their freedom of action without incurring the costs that accompany the need to gain access to thicket of intellectual property rights.

Earlier I noted briefly that patents on short snippets of the human genetic code are thought to be emerging as a major threat to effective pharmaceutical research. A large number of independent firms were filing patent applications on gene sequences, prompting fears that a large number of discrete, independently held patents would have to be licensed if a biotech or pharmaceutical firm sought to develop an effective therapeutic drug aimed at the product of that gene.

In 1995, Merck Pharmaceuticals, one of the world’s leading pharmaceutical research firms, stepped into the picture by announcing the creation of the Merck Gene Index – a public database of gene sequences corresponding to expressed human genes. Upon announcement, Merck released 15,000 expressed human gene sequences into the public domain and announced that it would characterize and make freely available as many gene sequences in as short a period of time as possible. By 1998, Merck published over 800,000 gene sequences.

Recent evaluations of the threat that patents on gene sequences pose to progress in biomedical research suggest that Merck’s strategy has significantly eased the anti-commons threat in this domain (Levang 2002). But, why would Merck make such an investment, which, according to one estimate, has cost them several million dollars? One interpretation is that Merck sees gene sequences as inputs rather than end products. By placing gene sequences in the public domain, Merck precludes patents for any sequence published prior to another firm’s isolation of the sequence. In response to the threat that one of its key inputs would be encumbered with excessive licensing fees and transaction costs, Merck set out to pre-empt the anti-commons dynamic that was emerging. In other words, it was worth privately creating a form of public good, as long as the blocking value of defensively publishing a gene sequence is greater than their immediate use value. Indeed, as long as no one succeeds in patenting, then everyone is better off. But if one firm succeeds then the usual logic of the prisoner's dilemma exerts is corrosive effect: all firms will want to obtain blockade positions if one firm does.

o A research agenda for the study of self-organizing institutions

The key lesson of this research is that in rapid and cumulative invention environments intellectual property rights often become fragmented among many firms in an industry. Marketable products require many IPR inputs and therefore many IPR transactions. Where firms are involved in such transactions repeatedly, institutions for regularized IPR exchanges tend to emerge. Because they grow out of repeat dealings by knowledgeable industry insiders, and because their internal governance allow for ongoing administrative adjustments, they are more efficient than a compulsory license or other forms of state intervention. The irony is that the pressure of high transaction costs in an industry where repeat dealings are the norm will produce a better transactional mechanism than a legislature could create in advance. Indeed, patent pools would not emerge except against the background ubiquitous litigation, production-choking injunctions, and high transaction costs. Similarly, enduring private investments in the public domain, like the one made by Merck, would not arise as a feasible and cost effective measure without the strong intellectual property rights that makes pre-emption of those rights a strategic imperative.

What remains now is the need to conduct a large-scale analysis of these institutions in order to determine what types of issues and underlying conditions are amenable to private ordering and tacit coordination.

By way of summary and conclusion I offer four more general propositions to subject to further testing in future research.

1. When new economic and technological circumstances arise, policymakers backed by powerful vested interests will impose an institutional regime that conforms to existing ideas and theories about how the economy works. Because their subjective models reflect ideas, ideologies, and beliefs that are, at best, only partially refined and improved by information feedback on the actual consequences of the enacted policies, the consequences of specific policies are not only uncertain but to a substantial degree unpredictable (North 1990: 104). These difficulties in forecasting the effect of formal institutional changes inevitably produce gaps and inefficiencies in the property rights framework. As a consequence, initial changes in formal institutions that seek to accommodate changes in technology and relative prices are likely to be incomplete at best.

2. Private ordering arises over time to mitigate transactional difficulties created by gaps and inefficiencies in the regulatory framework supplied by the state, providing, in some cases, effective substitutes for, or complements to, public regulatory action. Indeed, where the state blocks or fails to encourage the development of agents or institutions to navigate a complex transactional environment, it will be in the overwhelming interest of organized groups operating beyond the state to satisfy the unmet demand for transaction cost engineering.

3. Adaptive efficiency is concerned with both the kind of rules that shape the way an economy evolves through time, but also the way in which the rules themselves evolve. In a period of uncertainty brought on by change and complexity, no one knows the correct answer to the problems we confront and no one can, in effect, “maximize utility.” But, as Hayek observed long ago, the society that permits the maximum generation of trials will be most likely to solve problems through time (Hayek 1960). Adaptive efficiency, therefore, demands a formal incentive structure that encourages the development of decentralized decision-making processes that will allow societies to maximize the efforts required to explore alternative ways of solving problems.

4. Private actors working through even the most assiduously designed self-governing institutions are likely to confront limitations in their monitoring and enforcement capabilities. Hence, the role of the state in a decentralized legal or regulatory system is to provide targeted assistance to private institutional entrepreneurs, and where cost effective, to selectively elevate appropriate social norms and private institutions to the level of law (Cooter 1994). In practice, this suggests that the right way to formulate law in a complex economy is to a) allow an workable praxis to emerge among practitioners, b) identify the incentive structure that produced the praxis, and if that incentive structure is efficient, then c) adopt the praxis as the basis for codified and state-enforced laws.

In effect these propositions boil down to a realization that both the market and the polity fail to provide optimal institutional solutions in times of rapid technological and economic change. Fortunately, we need not “choose” between these alternative social arrangements exclusively; some of the most viable solutions to failures of the market and government are realized through the adaptations of private actors to limitations in both.